Monetary Exit and Fiscal Spillovers

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Abstract

The aftermath of the Global financial crisis has seen two types of monetary policy concerns. Some economists (e.g. Paul Krugman) worry primarily about possible deflation caused by a secular stagnation. In contrast, others (e.g. John Taylor) worry about excessively high inflation caused by quantitative easing and monetization of fiscal imbalances. We show that some countries should fear both - deflation in the short term and high inflation in the long term - whereas some countries are unlikely to experience either. This is done in a game theoretic framework with dynamic leadership (stochastic revisions of actions). Such framework enables us to examine *strategic* monetary-fiscal interactions as well as policymakers' incomplete information about the economic recovery (such as during 2010-2014). Our empirical section then quantifies indices of monetary and fiscal leadership for high-income countries to assess their deflationary/inflationary prospects. It is shown, for example, that undesirable departures from price stability, both in the short term and long term, are much more likely in the United States and Japan than in Australia or New Zealand.

Keywords: monetary-fiscal interactions; fiscal stress; deflation; active/passive policy regime; Game of chicken; asynchronous moves; dynamic leadership; stochastic timing; equilibrium selection. **JEL Classification Numbers:** E63, C70.

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1. Introduction

The post Global financial crisis (GFC) period of 2010-2014 has presented policymakers all over the globe with major challenges. In the monetary policy arena, high uncertainty about economic conditions has made it difficult to assess the threats that: (i) underperforming economies may fall into a *deflationary* trap in the short term; and that (ii) recent fiscal and monetary actions combined with unfavourable demographic trends may have *inflationary* consequences in the long term.[3]

In terms of the short term, the unemployment rate in the United States over 2010-2014 has been far above its natural rate despite interest rates at zero. Coupled with GDP growth rates and inflation consistently below the historical average this led to fears of a Japanese style prolonged slump. In terms of the long term, the balance sheet of the Federal Reserve increased in size more than fourfold during the GFC (from 8% to well over 20% of GDP) and the Congressional Budget Office's projections show steadily rising debt into the future. The situation in the rest of the advanced world is similar, whereby the World Economic Forum ranked 'fiscal crises' as the number one global risk in terms of the perceived financial losses (ahead of climate change and asset price collapse).[4]

We model both the short-run and long-run aspects of a post-downturn situation - focusing on the *strategic* interactions between the monetary and fiscal policymakers. The developments of the post-GFC period suggest that strategic considerations may be crucial in determining the outcomes of *both* policies - even if the central bank is formally independent from the government. For example, the European Central Bank's initial resistance to quantitative easing, and its subsequent change of view suggest that formal modelling of strategic monetary-fiscal interactions may produce novel insights. The importance of such interactions is likely to grow over time as countries face increasing fiscal stress from aging populations.

The main contribution of the paper is showing - via novel game theoretic methods - how institutional design of monetary and fiscal policy and uncertainty about the economy's recovery may affect the strategic policy interaction and the resulting departures from price stability. This qualitative analysis is complemented by a quantitative assessment in order to better predict short-term and long-term monetary and fiscal policy outcomes in advanced countries. Importantly, our findings are used to formulate policy recommendations for the post-GFC period. This is not only for single countries but also for currency unions such as the European monetary union, based on their formal examination in Section 7.

Let us be clear up-front: this is not a 'conventional' macro paper. As strategic interactions cannot be captured in standard microfounded models, we use instead a dynamic game with stochastic revisions of policy actions [developed in Libich and Stehlík (2011)]. As such, the paper answers Leeper's (2010) call for '*more dynamic modelling*' of the policy interaction at the game theoretic level rather than the macroeconomic level. Nevertheless, our results indicate that this type of dynamics deserves research attention.

[3]The paper does not examine the heat of the GFC itself (the 2008-2009 period), but rather the aftermath of the crisis (the 2010-2014 period). This is because in the former period there was little disagreement regarding desirable macroeconomic policy actions - virtually all countries implemented both monetary and fiscal stimuli.

[4]Appendix A provides a discussion of fiscal stress in advanced countries.

Furthermore, or generalized timing of moves and incomplete information enable us to follow Leeper's plea for '*more attention to information and uncertainty ... and more focus on institutional design*'.

2. Summary of the Setup, Findings, and Policy Implications

Our monetary vs fiscal interaction is a game between the central bank and the government featuring two main problems observed in the post-GFC period. The long-term problem is existence of an intertemporal budgetary shortfall [the so-called 'fiscal gap', see Kotlikoff (2006)]. The short-term problem is an underperforming economy following an adverse shock.

Economic Uncertainty and Policy Conflict. The solution of both problems is made difficult by two facts. First, the policymakers are uncertain about the economy's recovery prospects. Specifically, with probability $(1-p)$ they believe that economic conditions will keep improving, and the economy recovers at a good pace without any additional stimulatory measures. This is our '*Normal times*' scenario. In contrast, with probability p economic conditions are such that a prolonged slump and deflation are imminent in the absence of additional policy stimulus. This is our '*Downturn*' scenario. While we assume that the two policymakers have the same estimate of (an exogenous) p, we do not restrict this value. This reflects the fact that in the real world it varies over the business cycle.

The second 'complication' is that, due to the presence of a large fiscal gap, monetary and fiscal policymakers have conflicting objectives. In particular, each policymaker prefers the *other* policy to deal with the underlying problem: the weak recovery in the short term and the fiscal imbalance in the long term. Therefore, our analysis can roughly be interpreted as examining the following question: *'Which policy, if any, will be 'induced' to deal with the short-term threat of a double-dip recession, and which with the long-term fiscal shortfall?'* This embeds both a conflict and a coordination problem of the monetary and fiscal authorities, which is why the Normal times and Downturn scenarios take the form of the Game of Chicken and the Battle of the Sexes respectively.[5]

Timing of Policy Actions. Our methodological innovation based on Libich and Stehlík (2011) is to generalize the timing of the game allowing for arbitrary (stochastic or deterministic) revisions of moves. Specifically, after an initial simultaneous move (one of) the policymakers can revise the previous policy stance with some probability - but

[5] A number of monetary-fiscal interaction papers have the conflict and/or coordination features, for example Adam and Billi (2008, 2006), Branch, et al. (2008), Benhabib and Eusepi (2005), Dixit and Lambertini (2003a,b), Bassetto (2002), Barnett (2001), Blake and Weale (1998), Nordhaus (1994), Sims (1994), Woodford (1994), Leeper (1991), Petit (1989), Alesina and Tabellini (1987), or Sargent and Wallace (1981). While these papers contain a wide range of modelling approaches and macroeconomic environments, our insights relate to their common conflict/coordination features, and are therefore applicable to all these papers. An earlier version of this paper, Libich, Nguyen, and Stehlík (2012), shows how the Game of Chicken and the Battle of the Sexes can be derived under reasonable circumstances from a standard intertemporal budget constraint of the government and conventional quadratic policy preferences, as e.g. postulated in Leeper and Walker (2011).

not necessarily with certainty, and only with a delay.[6] This is in contrast to the standard repeated game in which moves are made simultaneously every period, alternating move games of Maskin and Tirole (1988) in which players move every other period, or the Stackelberg leadership in which the revision is immediate. Neither of these existing setups seems realistic in the monetary and fiscal policy context.

Our timing implies that, in contrast to the standard Stackelberg leadership concept which is static, our leadership concept is *dynamic*. In particular, in the standard framework the follower can revise his action without delay, i.e. there is no cost to the leader from mis-coordination or conflict. In contrast, our framework allows for such costs as the revision opportunity may arrive later in the game and payoffs accrue over time.

Equilibrium Outcomes. Our analysis shows how the equilibrium regimes, both short term and long term, depend on (i) the various costs and benefits of conflict and coordination, (ii) the probability p of being in the Downturn scenario, and most interestingly (iii) the policies' *relative* inability to change their previous stance. This is because this inability determines which policy imposes itself as the leader in the game, and how strongly so. Specifically, we identify three equilibrium regions determined by the $\frac{\text{monetary leadership}}{\text{fiscal leadership}}$ ratio:

(1) *Monetary-dominance* - the central bank is the leader and this ratio is above a threshold T_F;
(2) *Fiscal-dominance* - the government is the leader and this ratio is below a different threshold (that is a mirror image of T_F);
(3) *Regime-switching* - the ratio is in the intermediate interval.

In the Monetary-dominance case inflationary fiscal spillovers will surely be avoided in the long-run. This is because strong monetary leadership gives the central bank ammunition to counter-act an excessive fiscal stance. This region is implicitly assumed by most existing papers. In contrast, in the Fiscal-dominance case inflationary fiscal spillovers will surely occur in Normal times because fiscal leadership gives the government an upper hand in the policy tug-of-war. The monetary exit will be unsuccessful, similarly to the intuition of Sargent and Wallace's (1981) unpleasant arithmetic and Leeper's (1991) fiscal theory of the price level. Importantly, we show how in both dominance regions deflation is prevented in the short-term equilibrium. This is because the dominant policy can indirectly induce the dominated policy to provide the required stimulus in the Downturn scenario.

The Regime-switching region is of particular interest as it does not exist under static (Stackelberg) leadership. In this region leadership no longer ensures a player's dominance. One policy is still the leader in the game, but insufficiently so to force the opponent to cooperate. This increases the likelihood of a policy tug-of-war, which is costly for both policymakers and society. The conflict has the form of a 'waiting game'; both policies delay required actions hoping to induce the other policy to carry them out. In the Downturn scenario they postpone necessary (conventional or unconventional) stimulatory measures making a double-dip recession accompanied by deflation likely. In

[6]The timing of the revision opportunity, described by an arbitrary probability distribution, is assumed exogenous and common knowledge, but it can be easily postulated as private information and/or endogenized.

Normal times they postpone dealing with the fiscal gap which brings the economy closer to a fiscal crisis and debt monetization.

This means that countries in the Regime-switching region are more likely to see *both* deflation in the short term and high inflation in the long term compared to those in the Monetary-dominance region.[7] Furthermore, we find that under realistic circumstances the threshold T_F is increasing in p. Therefore, a certain degree of monetary leadership that is sufficient to shelter monetary policy from fiscal pressures, and ensure price stability in Normal times, may be insufficient in the aftermath of a downturn such as the GFC. None of these findings can be obtained under static leadership, which highlights the importance of using dynamic leadership to avoid inaccurate policy prescriptions.

Policy Implications. In Section 6 we relate our findings to the real world. We develop summary indices of fiscal and monetary leadership based on twelve existing institutional measures in the literature. The analysis shows that while countries such as Australia and New Zealand seem safely in the Monetary-dominance region, countries such as the United States and Japan are likely in the Fiscal-dominance or Regime-switching regions. This implies a higher probability of both short-term deflation and long-term high inflation in the U.S. and Japan than in Australia or New Zealand.

Our analysis's main implication for monetary policy in the aftermath of the GFC is as follows. In order to minimize the probability of both deflation in the short-term, and of subsequent inflationary fiscal spillovers (i.e. maximize the credibility of a monetary exit from the GFC), the central bank should be as strongly committed as possible in the long-term to achieve the Monetary-dominance region. Such strong monetary leadership acts as a '*credibility insurance*' over the business cycle, as it delivers price stability for all values of the Downturn probability p.

In practice, monetary leadership has been implemented through a legislated numerical target for average inflation. A recommendation to adopt such explicit commitment has been made by a number of economists, both for short-run and long-run reasons, e.g. Bernanke (2003), Goodfriend (2005), Hamilton (2008), or Walsh (2009). For example, Mishkin (2010) argued, in line with our findings, that *'By establishing an inflation objective ... the Fed can guard against both of these problems. Providing a firm anchor for long-run inflation expectations would make the threat of deflation less likely. But a firm anchor would ... [make] an upward surge in inflation expectations less likely too.'* The fact that the Federal Open Market Committee (FOMC) subscribed to the 2% long-term inflation target more explicitly in its January 2012 statement may have had these motives.[8]

Interestingly, our analysis implies that an explicit monetary commitment may improve not only monetary outcomes, but also fiscal outcomes. By reducing the structural incentives of the government to spend excessively through a credible threat of a policy conflict, stronger monetary leadership can under some circumstances discipline fiscal

[7] It is important to note that this result is *not* due to the short-term economic problems spilling over to the long-term (i.e. the attempts to stimulate the weak economy contributing to a fiscal crisis). The result is due to the political and institutional characteristics in some countries prone to a monetary-fiscal policy conflict, leading to departures from price stability in both directions over the business cycle.

[8] It is important to note that the commitment to low average inflation does not need to be focused on consumer prices, but can in principle use a broader measure of inflation.

policy and induce necessary fiscal reforms. We report below some empirical evidence for this 'disciplining effect'.

Nevertheless, in our extension to the case of a monetary union in Section 7 we identify an important caveat. If a free-riding problem exists in the union, whereby some governments do not internalize the negative externality their fiscal profligacy imposes on other union members, then even an infinitely strong leadership of the common central bank may be ineffective in disciplining small free-riding governments. We show that in such case some countries in the union are likely to experience deflation in the short-term, and the union as a whole may experience higher inflation in the long-term.

The policy implication is that countries considering accession to a monetary union have to factor in the possible reduction of the central bank's disciplining influence on fiscal policy. And therefore design their fiscal rules more carefully to offset this reduction.

3. The Policy Interactions Under Incomplete Information

Our attempt is to capture the key characteristics of the strategic monetary-fiscal interaction in the post-GFC situation. We spell out eight assumptions that arguably apply to the 2010-2014 period and have implications for macroeconomic outcomes.[9] Despite our efforts, formalizing all these assumptions in a microfounded macro model - in a way that allows one to examine *strategic* policy interactions - seems impossible. We therefore focus on the game theoretic insights without postulating an underlying macro model.[10] Nevertheless, we are transparent in the sense of spelling out all our assumptions and justifying them with reference to the 2010-2014 global economic situation. Further, Section 7 discusses extensively how our findings relate to this situation and formulates some policy recommendations.

Monetary (M) and fiscal (F) policy can engage in an '*active*' (A) or '*passive*' (P) stance, which is summarized in the following 2×2 game of incomplete information (with $a, ..., z'$ denoting the payoffs)

(1)

		F	
		PF	AF
M	AM	a, w	b, x
	PM	c, y	d, z

Normal times: probability $1 - p$

		F	
		PF'	AF'
M	AM'	a', w'	b', x'
	PM'	c', y'	d', z'

Downturn: probability p

Consider the Normal times scenario depicted in the left part of (1). Following the intuition of Leeper (1991), the A policy stance does not provide a (sufficient) adjustment to balance the long-term budget constraint, whereas the P policy stance does.

[9] Some of the assumptions do not necessarily apply to the peak of the crisis itself, i.e. the 2008-2009 period. As stated above, we are however interested in the aftermath of an adverse shock such as the 2010-2014 period, in which uncertainty about the recovery and about the optimal monetary and fiscal policy mix becomes a major issue.

[10] Interested readers can see an earlier version, Libich, Nguyen, and Stehlík (2012), which offers a simple macro setup featuring standard quadratic policy preferences and an intertemporal budget constraint of the government based on Leeper and Walker (2011). It shows how the game theoretic representation of (1) including the payoffs can be derived from the macro model. While this analysis offers the intuition, it is too much of a 'reduced-form' and lacks macroeconomic dynamics. We therefore do not reproduce it here and focus on the dynamics embedded in the game with stochastic revisions.

Specifically, passive fiscal policy PF can solve the budgetary problem in Normal times via a fiscal reform in which future government expenditures and taxes are aligned.[11] As a partial substitute, passive monetary policy PM can balance the budget constraint by inflating the accumulated debt away as per Sargent and Wallace (1981).

In the Downturn scenario shown in the right part of (1), PM' can thus be interpreted as monetary stimulus due to its short-term expansionary effect. Similarly, AF' represents a fiscal stimulus since government expenditures exceed tax revenues.

3.1. **Normal Times.** We make the following assumptions about the Normal times scenario (which is expected by both policymakers to occur with probability $1-p$). First, there exists a sizeable fiscal gap - unfunded public liabilities mandated by the existing legislation. This is uncontroversial given the observed demographic trends, see Appendix A for some data and a discussion. Second, we assume that in the Normal times equilibrium the budget constraint has to be satisfied, i.e. one policy must be passive. This effectively rules out default on debt as an ongoing long-term solution to the fiscal imbalance. Third, both policymakers prefer the *other* policy to play P and balance the budget constraint, i.e. $a > d$ and $z > w$. This is because the central bank dislikes systemic deviations from price stability, and the government dislikes reneging on promised transfers to the public.

The assumptions imply that while in the (AM, PF) and (PM, AF) regimes the budget constraint is balanced by fiscal and monetary policies respectively, in the (AM, AF) regime neither policy is adjusted. Therefore, debt is on an explosive path, both in nominal and real terms, and the latter regime cannot be an equilibrium in Normal times. Formally, this implies $b < \min\{a, d\}$ and $x < \min\{w, z\}$. Finally, in the (PM, PF) regime both policies attempt to balance the budget constraint in an uncoordinated fashion. Therefore, real debt is actually falling due to excessive inflation which is in no player's interest. Formally, we have $c < \min\{a, d\}$ and $y < \{w, z\}$.

Combining the above, our three assumptions mean that the payoffs in (1) satisfy

$$a > d > \max\{b, c\} \quad \text{and} \quad z > w > \max\{x, y\}. \tag{2}$$

The following payoff matrix offers a numerical example, with the Nash equilibria indicated in bold

(3)

		F	
		PF	AF
M	AM	Ricardian $\mathbf{3}, \mathbf{2}$	explosive (tug-of-war) $1, 1$
	PM	mis-coordination $0, 0$	monetization (spillovers) $\mathbf{2}, \mathbf{3}$

Game of Chicken

It is apparent that the Normal times scenario has the structure of the Game of Chicken. The intuition of this game closely resembles the unpleasant monetarist arithmetic of Sargent and Wallace (1981). There are two pure strategy Nash equilibria, each preferred

[11] Note that PF can also be interpreted as an intertemporarily balanced budget (including factors such as the government's implicit guarantees for financial institutions). This is in line with Leeper and Walker (2011) who highlight *'the importance of building in the possibility of adopting a policy rule that incorporates a balanced budget.'*

by a different player. The central bank wants to deliver stable prices, and an intertemporarily balanced budget allows the bank to do so. Therefore, the bank prefers the socially optimal 'Ricardian' regime (AM, PF). In contrast, the government prefers to avoid necessary fiscal reforms for political economy reasons, and would like the central bank to inflate the accumulated debt away. Therefore, the government's preferred outcome is the 'non-Ricardian' regime (PM, AF).[12] If the policymakers do not coordinate their actions, for example if they play the mixed strategy Nash equilibrium, they get inferior off-diagonal outcomes for at least some part of the game.

3.2. **Downturn.** Attempting to capture the GFC environment we make the following five assumptions about the Downturn scenario (which is believed by the policymakers to occur with probability p).

First, as adverse economic conditions continue, the economy requires a potent expansionary response in order to fully recover. If neither policy responds, or we only have a Ricardian type response in which future taxes are expected to rise, the economy experiences a prolonged recession and possibly a deflationary trap. Formally, this means $a' < \min\{b', c'\}$ and $w' < \{x', y'\}$.

Second, monetary and fiscal policies are (partial) substitutes in providing the required stimulus. This can be interpreted both in terms of conventional policies (lower interest rates and higher government spending respectively), as well as unconventional ones (the central bank's quantitative easing, QE, and government's debt management). In terms of the latter Barro (2010) notes: *'My conclusion is that QE2 may be a short-term expansionary force, thereby lessening concerns about deflation. However, the Treasury can produce identical effects by changing the maturity structure of its outstanding debts.'*

Third, the intertemporal budget constraint may not be satisfied in the Downturn equilibrium. As a justification of this assumption, see e.g. Davig and Leeper's (2010) estimates showing the occurrence of the active/active regime under U.S. President Reagan and Fed Chairman Volcker.[13]

Fourth, we assume that a joint expansionary response of the policies, (PM', AF'), may be excessive and over-heat the economy, potentially planting seeds for imbalances in the future. This assumption can be motivated by the developments following the burst of the NASDAQ dot-com bubble, e.g. Taylor and Ryan (2010) argue: '*The Fed's decision to hold interest rates too low for too long from 2002 to 2004 exacerbated the formation of the housing bubble.*'[14] This assumption implies $d' < \min\{b', c'\}$ and $z' < \min\{x', y'\}$.

Fifth, both policymakers prefer the *other* policy to stabilize the shock: the central bank prefers (AM', AF'), whereas the government prefers (PM', PF'). Formally, $b' > c'$ and $x' < y'$. This is because the policymakers understand that their additional

[12]Such government preferences can be derived from an overlapping generations model with an aging population. See Kuehnel (2011) for formal modelling of how this '*shifts political power from the young to the old*'. Davig and Leeper (2010) show that since 1985 the Ricardian and non-Ricardian regimes were most prevalent in the U.S., which also indicates the Game of Chicken.

[13]This assumption, together with the first, are the two key differences between the Normal times and Downturn scenarios.

[14]Similar concerns can be heard about the policy behaviour in the post-GFC period, e.g. Rajan (2011). They are highlighted by the striking near perfect positive correlation between the size of the Fed's balance sheet and U.S. stock indices since 2009.

stimulatory measures jeopardize the pursuit of their preferred Normal times regime once the Downturn threat is over. For example, central banks may resist further QE on the grounds that it will make the subsequent exit strategy harder and less credible. As Barro (2010) argues: *'The downside of QE2 is that it intensifies the problems of an exit strategy aimed at avoiding the inflationary consequences of the Fed's vast monetary expansion.'* Similarly, additional conventional fiscal measures deteriorate the long-run fiscal position, and make it difficult for the government to engage in politically popular spending programs in the future. The same is true for unconventional fiscal measures that increase the debt rollover risk.

The following remarks from Fed Chairman Bernanke (2011) clearly express the monetary preference for (AM', AF'), that is, $b' > c'$: '*I have advocated that the negotiations about the budget focus on the longer term ... in light of the weakness of the recovery, it would be best not to have sudden and sharp fiscal consolidation in the near term. That doesn't do so much for the long-run budget situation, it's a negative for growth.'*

It is straightforward to see that our five assumptions of the Downturn scenario imply

$$b' > c' > \max\left\{a', d'\right\} \quad \text{and} \quad y' > x' > \max\left\{w', z'\right\}. \tag{4}$$

A numerical example is offered in the following payoff matrix

(5)

		F	
		PF'	AF'
M	AM'	deflation $0, 0$	recovery $\mathbf{3}, \mathbf{2}$
	PM'	recovery $\mathbf{2}, \mathbf{3}$	over-stimulating $1, 1$

Battle of the Sexes

which constitutes the Battle of the Sexes game.

3.3. **Equilibria Using Standard Timing Setups.** A large body of the policy interactions literature (see footnote 5) features both a coordination problem and a policy conflict. They thus point to the Game of Chicken and the Battle of the Sexes. While the former is an anti-coordination game and the latter is a coordination game, they are similar. Both have two Pareto-efficient pure strategy Nash equilibria, each preferred by a different player, and one mixed strategy Nash equilibrium that is Pareto-inferior to both pure Nash equilibria - for both players.

What is the solution of these games? Under simultaneous moves, neither standard nor evolutionary game theory provide a way of selecting between the pure Nash equilibria in the Game of Chicken and the Battle of the Sexes due to the symmetry. The Pareto-inferior mixed Nash with regime switching is therefore a possibility in both games, and a reason for concern.[15] To offer some clarity, a common solution has been to apply Stackelberg leadership. Most famously, Sargent and Wallace (1981) focus on the case of the government being the Stackelberg leader in the Normal times situation, and the central bank the follower. Leadership gives the government an upper hand and enables it to achieve its preferred policy regime by forcing the central bank into a monetary

[15]There exists evidence of regime switching in the United States. Davig and Leeper's (2010) paper shows over a dozen regime switches in the U.S. since 1950, with all four our Normal times policy regimes present.

solution to the fiscal gap. In the alternative case of Monetary-dominance the opposite is true and such unpleasant monetary arithmetic is avoided.

The next section generalizes the Stackelberg leadership concept from static to dynamic, and shows that these conventional findings are refined and partly qualified.

4. Generalized Timing of Moves

Macroeconomic models have commonly been studied using a one-shot game, or its repeated analog. In both of these settings players' moves are always simultaneous, which is arguably unrealistic in the macroeconomic policy context.[16] In order to relax such synchronicity assumption and incorporate institutional characteristics we will generalize the timing as follows:

(1) Expecting the Downturn and Normal times scenarios with probability p and $1-p$ respectively, the players move simultaneously at time $t = 0$.
(2) One of the players, called *reviser*, can move again in time $t \geq 0$ with some (ex-ante known) positive probability. The player does so observing the initial play of the opponent, called the *leader*, who has to stick to his initial choice to the end of the dynamic stage game (normalized to $t = 1$).
(3) Payoffs accrue continuously over $t \in [0, 1]$.

Our framework allows for an arbitrary timing of the revision opportunity. The top panels of Figure 1 offer three examples: normal, uniform, and binomial distributions, the latter in line with the popular Calvo (1983) scheme.[17]

Section 6 relates real world institutional characteristics to this timing. It implies that in countries with a high degree of fiscal leadership (a large fiscal gap) and weak monetary leadership (absence of a legislated inflation target) the government will have the role of the leader. It is able to reconsider its fiscal stance (at most) once a year in the proposed budget, whereas the central bank as the reviser is able to reconsider its monetary stance every 4-6 weeks at its regular meeting. This can be depicted as the right panel of Figure 1 where the time frame of the game $t = 1$ can then be interpreted as one year.

In contrast, in countries in which the fiscal gap is small and monetary commitment is explicitly legislated the central bank is no longer a reviser; it becomes the leader in the game. For example, the Policy Target Agreement in New Zealand specifies that the inflation target can only be altered when a new government or central bank Governor take office, i.e. roughly every four years. In such case, the players' roles in the right

[16] It should be noted that most existing micro-founded macroeconomic models implicitly assume a simultaneous move. This is because monetary and fiscal policies, like expectations, can be adjusted every period.

[17] In the game theoretic paper Basov, Libich, and Stehlík (2013) we allow *both* players to revise their initial actions on $t \in [0, 1]$. While the solution of the game is more complex, the intuition is similar because what matters is the players' *relative* inability to revise actions. Let us also note that while the dynamic stage game can be repeated, we do not do so since our focus is on deriving circumstances under which the dynamic stage game itself has a unique and efficient subgame perfect equilibrium. In such case repetition does not alter the outcomes. Nevertheless, allowing for reputation building would have the standard effects of improving coordination and reducing the probability of inferior outcomes, see Mailath and Samuelson (2006). Libich and Stehlík (2011) offer a detailed mathematical treatment of several specific timing distributions, including their combinations. They also discuss the differences from 'stochastic games' of Shapley (1953).

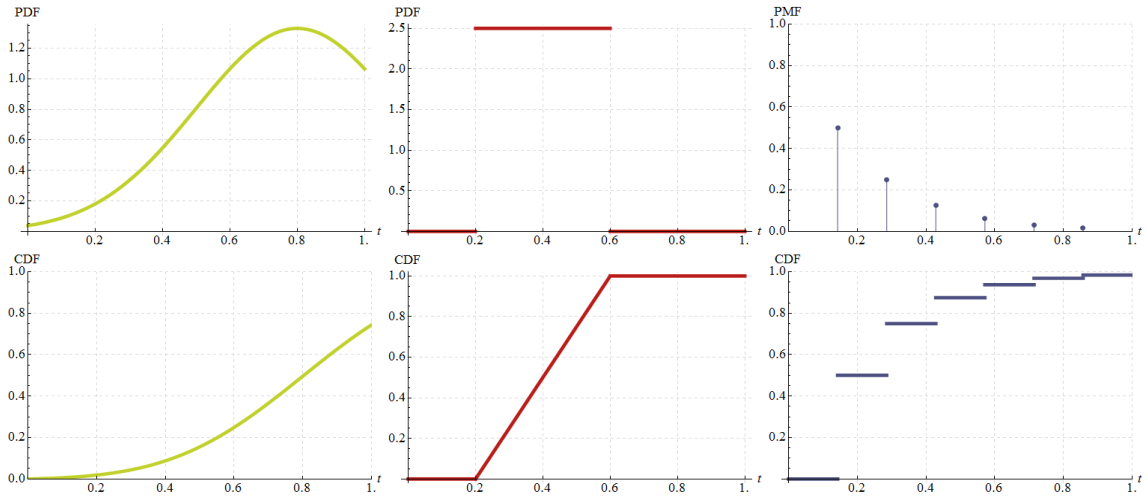

FIGURE 1. Three examples of timing: truncated normal, uniform, and binomial distributions (top panels), and their corresponding cummulative distribution functions as per Definition 1 (bottom panels).

panel of Figure 1 are reversed and the government is the reviser. The time frame of the game $t-1$ becomes four years whereby the government's annual budgets serve as its revision opportunities. The following definition describes several related concepts used in our analysis.

Definition 1. *(i) The cumulative distribution function (CDF) summarizes the probability that by time t the reviser has had a revision opportunity (see the bottom panels of Figure 1). We call it the* ***revision function****, and denote it by $R_i(t)$, where $i \in \{M, F\}$ is the reviser.*
(ii) Based on i's ***revision speed*** *we will distinguish three cases:*

$$\int_0^1 R_i(t)\mathrm{d}t \begin{cases} = 1 & \textit{(standard)} \textbf{\textit{ static leadership}}, \\ \in (0,1) & \textbf{\textit{dynamic leadership}}, \\ = 0 & \textit{(standard)} \textbf{\textit{ simultaneous move.}} \end{cases} \tag{6}$$

(iii) The reciprocal of the complementary CDF,

$$\frac{1}{\int_0^1 (1 - R_i(t))\,\mathrm{d}t} \in [1, \infty],$$

expresses the leader's ***degree of leadership*** *- relative to reviser i.*[18]

The setup makes clear that the standard frameworks of simultaneous moves and Stackelberg leadership are only extreme cases. This calls into question the robustness of conventional results.

[18]Naturally, we have $\int_0^1 (1 - R_i(t))\,\mathrm{d}t = 1 - \int_0^1 R_i(t)\mathrm{d}t$.

5. Results

In order to highlight the effect of dynamic leadership representing institutional factors and constraints, we compare them to the standard simultaneous move game and the static leadership.

5.1. **Simultaneous Moves.** This is our special case $\int_0^1 R_i(t)\mathrm{d}t = 0$ whereby there is no area below the CDF. The players' payoff from each regime is a weighted average of those in Downturn and Normal times with p as the weight, e.g. $a'' = (1-p)\,a + pa'$. It is apparent that even if (2) and (4) hold, i.e. the underlying games are known to be the Game of Chicken and the Battle of the Sexes, under incomplete information we may have many different classes of games. The ranking of the regimes by each policymaker depends on the exact values of the payoffs in the two scenarios and the probability p. Hence there is a large number of possible (Bayesian Nash) equilibria. The implication can be summarized as follows.

Remark 1. *Uncertainty about the business cycle compounds the coordination problem between monetary and fiscal policy.*

5.2. **Static Leadership.** This is our case $\int_0^1 R_i(t)\mathrm{d}t = 1$ whereby the revision is immediate so there is no area above the CDF. Under both static and dynamic leadership, we are interested in deriving the circumstances under which the leader fully dominates, i.e. the dynamic stage game has a *unique* subgame perfect equilibrium payoff preferred by the leader.

Proposition 1. *(i)* ***(Fiscal-dominance)*** *Under static fiscal leadership, inflationary fiscal spillovers onto monetary policy occur under* ***all*** *circumstances in the long-term, i.e. for any p and any payoffs satisfying (2) and (4).*
(ii) ***(Monetary-dominance)*** *Under static monetary leadership, fiscal spillovers onto monetary policy occur under* ***no*** *circumstances in the long-term.*
(iii) Under static leadership, deflation occurs under ***no*** *circumstances in the short-term.*

The long-term part of the proposition is in line with Sargent and Wallace (1981), in which leadership is an advantage that allows to force the opponent into compliance. The intuition of the short-run game is analogous: the leader can induce the follower to attend to the temporary economic weakness by a stimulus, so a double-dip recession caused by a policy conflict does not occur.

5.3. **Dynamic Leadership.** This section shows that while the intuition of Proposition 1 still applies the results are not robust under more general timing. It will become apparent that static leadership may provide misleading predictions, e.g. it down-plays the possibility of deflation arising from a policy tug-of-war. This is because leadership, while necessary, is not sufficient to ensure a player's dominance.

Proposition 2. *(i)* ***(Fiscal-dominance)*** *Under dynamic fiscal leadership, inflationary fiscal spillovers onto monetary policy* ***surely occur*** *if and only if the ratio of* ***monetary***

vs fiscal leadership is sufficiently low,

$$\frac{1}{\int_0^1 (1 - R_M(t))\,\mathrm{d}t} > T_M = \frac{\overbrace{p\left(y' - w'\right) + (1-p)\left(z - x\right)}^{F\text{'s weighted conflict costs}}}{\underbrace{p\left(y' - x'\right) + (1-p)\left(z - w\right)}_{F\text{'s weighted victory gains}}}. \tag{7}$$

(ii) ***(Monetary-dominance)*** *Under dynamic monetary leadership, inflationary fiscal spillovers onto monetary policy* ***surely do not occur*** *if and only if the ratio of* ***monetary vs fiscal leadership is sufficiently high***,

$$\frac{1}{\int_0^1 (1 - R_F(t))\,\mathrm{d}t} > T_F = \frac{\overbrace{p\left(b' - a'\right) + (1-p)\left(a - b\right)}^{M\text{'s weighted conflict costs}}}{\underbrace{p\left(b' - c'\right) + (1-p)\left(a - d\right)}_{M\text{'s weighted victory gains}}}. \tag{8}$$

(iii) ***(Regime-switching)*** *If neither of the two conditions (7)-(8) hold then inflationary fiscal spillovers onto monetary policy* ***may or may not occur*** *in the long-run. Furthermore,* ***deflation may occur*** *in the short-run, unlike in the two dominance cases (i)-(ii), and unlike under static leadership.*

Proof. Appendix B presents the proof, and Figure 2 depicts the results graphically. □

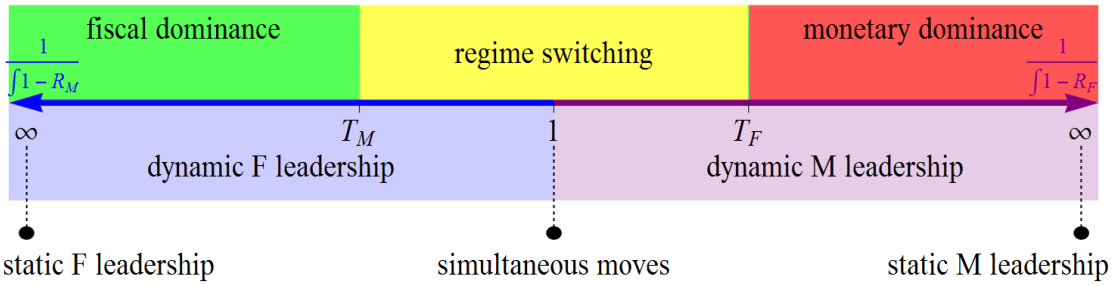

FIGURE 2. The top part shows the $\frac{\text{monetary-leadership}}{\text{fiscal-leadership}}$ space under dynamic leadership - including the thresholds T_i that separate the three equilibrium regions. The bottom part shows how our framework nests the standard timing setups.

To demonstrate the intuition consider the special case $p = 1$. Specifically, focus on the government being the leader relating to claim (i).[19] Solving backwards, the government knows that through its own inaction it can force the central bank to expand the economy when the bank's revision opportunity arrives. This rewards the government for pursuing its preferred outcome $(PM', PM'; PF')$. Nevertheless, as the initial waiting game is costly - potentially leading to deflation - the government's victory reward has to more

[19]Obviously, the reviser can never dominate the game, i.e. being the leader is a necessary condition for a player's dominance.

than compensate its initial cost. Formally, for the government to dominate the game PF' must be the unique best response not only to the simultaneously played PM', but also to AM', i.e. it must hold that

$$\underbrace{w' \int_0^1 (1 - R_M(t))\,\mathrm{d}t}_{(AM',PF')\text{: policy conflict}} + \underbrace{y' \int_0^1 R_M(t)\mathrm{d}t}_{(PM',PF')\text{: } F \text{ victory}} > \underbrace{x'}_{(AM',PF')\text{: } F \text{ surrender}}.$$

Rearranging this yields the following condition

$$\overbrace{\frac{1}{\int_0^1 (1 - R_M(t))\,\mathrm{d}t}}^{F\text{'s relative leadership}} > T_M = \frac{\overbrace{(y' - w')}^{F\text{'s conflict cost}}}{\underbrace{(y' - x')}_{F\text{'s victory gain}}},$$

which is the special case of (7) under $p = 1$. If satisfied, the central bank will surrender from the start and there is in fact no conflict in equilibrium. The government's threat of inaction becomes credible, and forces the central bank into a stimulatory action, which prevents deflation.

Formally, the area below the CDFs in Figure 1, $\int_0^1 R_M(t)\mathrm{d}t$, over which the government's victory gain accrues, is sufficiently large relative to the conflict cost area above the CDF, $\int_0^1 (1 - R_M(t))\,\mathrm{d}t$. Put differently, monetary policy is expected to be able to revise quickly, which implies a small potential cost to the government from the conflict.

It should now be apparent that if the central bank is the leader, the case of claim (ii), the T_F threshold is just a mirror image of T_M. The intuition is simply reversed: it is now the central bank willing to undergo a costly conflict with the government, which gives the bank an upper hand against the government.

5.4. **Game Theoretic Insights.** Let us highlight the game theoretic findings under dynamic leadership (the macroeconomic policy findings are discussed in the next section). Our analysis refines the results obtained under the simultaneous move and static leadership.

First, it shows that the leader may not always dominate. This is because its relative leadership may be insufficiently strong: in the interval $\frac{1}{\int_0^1 (1 - R_i(t))\mathrm{d}t} \in (1, T_i)$. In fact, the Regime-switching region may be much larger than the two dominance regions. Second, the analysis identifies several variables that determine the required degree of leadership for a policy to dominate. In particular, the thresholds T_F and T_M in (7)-(8) are increasing functions of the leader's conflict costs relative to his victory gain - in Downturn and Normal times weighted by the probability p. Third, the analysis shows how uncertainty about the business cycle may relate to the effectiveness of institutional design features such as an explicit inflation target. Specifically, if the $\frac{\text{conflict cost}}{\text{victory gain}}$ ratio in Downturn exceeds that in Normal times, which seems to be the case, then both T_F and T_M are increasing in p. In such case a higher p increases the size of the Regime-switching region. It therefore reduces the range of parameters over which the socially optimal outcomes occur, and deflation becomes more likely. These messages are different from those obtained under static leadership.

6. Relating the Analysis and Results to the Real World

This section highlights the linkages between our analysis and the post-GFC economic environment. It does so more extensively than is perhaps common, but we believe the challenges facing advanced economies warrant such an increased level of policy discussions. Table 1 summarizes the occurrence of short-term deflation and long-term high inflation in the three identified regions.

Equilibrium region	Monetary vs fiscal leadership ratio	Deflation in the Downturn equilibrium?	High inflation in the Normal times equilibrium?
Fiscal dominance	low	no	yes
Regime switching	intermediate	possible its probability is increasing in $\int_0^1 (1 - R_M(t))\, dt$ and in $\int_0^1 (1 - R_F(t))\, dt$	possible its probability is increasing in $\int_0^1 R_M(t) dt$ and in $\int_0^1 (1 - R_F(t))\, dt$
Monetary dominance	high	no	no

Table 1. Equilibrium regions and monetary policy outcomes.

In which of these equilibrium regions are real world economies located? How do changes in the policies' institutional design affect their transitions across the regions? Answering questions such as these is essential for predicting macroeconomic outcomes and formulating policy recommendations regarding the 2010-2014 period and similar post-shock periods in the future.

6.1. **Interpretation of the Revision Probabilities.**

Let us start by giving a more precise real world interpretation to our key institutional concept of dynamic monetary and fiscal leadership. Arguably, the players' inability to revise their previous stance relates to constraints placed on the policies by past/present legislation.

The degree of fiscal leadership naturally increases in the size of the fiscal gap, which in turn is determined by legislation relating to mandatory expenditures (e.g. health, social security, and welfare), taxes (e.g. promised tax cuts), as well as the extent of debt servicing. The greater the long-term shortfall between future mandatory government expenditures and taxes, the harder it may be for the government to implement reforms towards sustainability. Such incapability essentially gives the government the role of a leader in the game.

Similarly, the degree of monetary leadership depends on the extent to which the commitment to price stability is grounded in the central bank legislation/statutes. Arguably, monetary leadership is increased when a numerical target for average inflation

and the accountability provisions are legislated. This is because such a transparent objective cannot be easily reconsidered - due to political, institutional, and reputational constraints.[20]

6.2. **Quantifying Fiscal and Monetary Leadership.** In an attempt to assign real world countries to the three derived equilibrium regions, this section offers a way of quantifying the $\frac{\text{monetary leadership}}{\text{fiscal leadership}}$ ratio. We develop an index of both institutional variables based on established indices in the literature. To ensure robustness we average over a number of existing measures.

In terms of fiscal leadership, our index is a simple average of eight components based on: (i) the fiscal space concept of Aizenman and Jinjarak (2011), (ii) the estimated probabilities of a given fiscal space by Ostry el al. (2010), (iii) the fiscal space, fiscal path, and fiscal governance of Augustine el al. (2011), and (iv) average fiscal balances over 2000-11. For details see Table 2 in Appendix C. In terms of monetary leadership, we use four components based on: (i) the political transparency measure of Eijffinger and Geraats (2006) as calculated by Dincer and Eichengreen (2011), (ii) the final responsibility measure of the central bank accountability index of Haan et al. (1998) as updated by Sousa (2002), and (iii) the inflation focus and central bank accountability measures of Fry et al. (2000).[21] For details see Table 3 and for the original data see Table 4, both in Appendix C.

Appendix C also explains how we adjust for different units and mean levels of these measures in order to show not only the institutional ranking of countries, but also retain the quantitative differences between them implied by the underlying measures. Figure 3 presents our fiscal leadership scores from Table 6 for the 25 countries for which at least 5 out of the 8 measures have been calculated in the underlying papers. It is interesting to note the large differences that exist across countries, with the lowest degree of fiscal leadership in Australia, New Zealand, and Scandinavian countries, and the highest in Japan and Southern Europe.

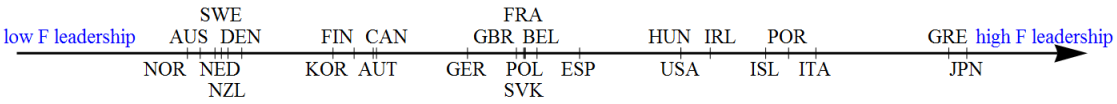

FIGURE 3. Fiscal leadership scores.

[20]The New Zealand Policy Target Agreement is a good example of such constraints. It implies that changes to the legislated inflation target can only be done infrequently (at pre-specified occasions when the Governor or government change), and that the Governor of the central bank is personally accountable for achieving the target.

[21]We have also considered the monetary commitment index by Freytag (2001), but do not use it because of its broad focus (it also includes criteria regarding central bank independence, bank supervision, exchange rate, and currency convertibility). For the relationship between inflation targeting, transparency, and accountability see e.g. Walsh (2003).

6.3. **Countries and Equilibrium Regions.** Using our monetary and fiscal leadership scores, Figure 4 offers the monetary vs fiscal leadership space whereas Figure 5 plots the leadership ratios. Unlike the former, the latter figure does so only for a subsample of countries that have an autonomous monetary policy (i.e. neither use nor are pegged to the Euro) - for reasons discussed in Section 7.

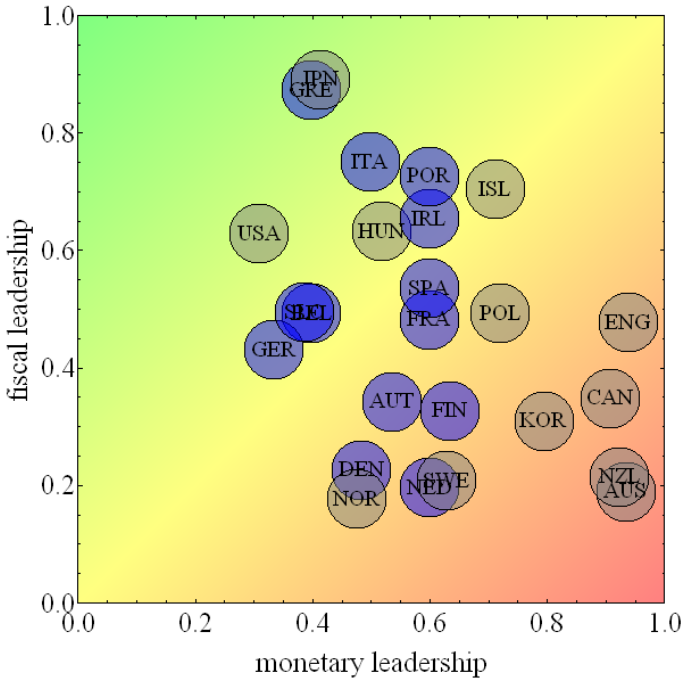

FIGURE 4. The monetary vs fiscal leadership space.

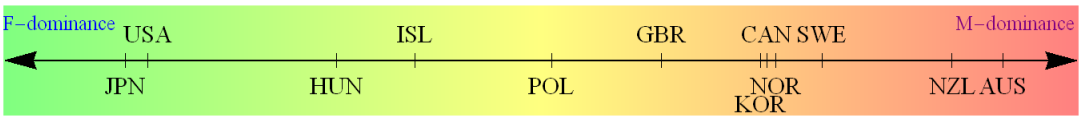

FIGURE 5. The ratios of monetary vs fiscal leadership scores.

While the ranking of countries in the latter figure can be done with some degree of confidence, assigning countries to our three equilibrium regions, that is, identifying the exact position of the thresholds T_M and T_F, is more problematic. As our theoretic results show, these are a function of a number of (hard to quantify) variables, and we therefore do not attempt to do so. This is indicated in Figures 4 and 5 by the transition between the colours being gradual - unlike that of Figure 2. Keeping that in mind, we will discuss observed developments focusing on two advanced countries from opposite sides of the $\frac{\text{monetary leadership}}{\text{fiscal leadership}}$ space: the United States and Australia.

6.3.1. *The United States.* Davig and Leeper (2010) show that the Ricardian regime occurred during 1984-1991 and again during 1995-2001, whereas the non-Ricardian regime (PM, AF) prevailed between 2002 and 2008. This is consistent with Li, Li, and Yu (2011) whose estimates suggest that the Fed has not been adhering to the Taylor principle since the early 2000s.

In terms of the Downturn scenario, Economist (2011) reports that between mid-November 2010 and end-March 2011 '*America's Treasury has issued some $589 billion in extra long-term debt, of which the Fed has bought $514 billion*'. The Economist concludes: '*In effect, QE ... has been undermined by debt-management policy*'. This implies (PM', PF') in our setting with monetary policy predominantly carrying out the required stimulus over the 2010-2014 period.

Such observed combination of the (PM', PF') and (PM, AF) regimes can, in equilibrium, occur with certainty in the Fiscal-dominance region, and with positive probability in the Regime-switching region. Nevertheless, neither regime can occur in the Monetary-dominance region. This implies that the $\frac{\text{monetary leadership}}{\text{fiscal leadership}}$ in the United States is to the left of the T_F threshold in Figure 5, and possibly also to the left of the T_M threshold.

While any such predictions must be made with a great amount of caution, at face value these outcomes suggest both a positive probability of short-term deflation, and (possibly much larger) probability of long-term high inflation in the United States (in the absence of structural and institutional policy changes). Such conclusion is further highlighted by the fiscal policy dead-lock in the U.S. evident during the repeated debt ceiling negotiations. As a consequence, Feldstein (2012) discusses the Fed's exit strategy consisting of paying interest on banks' excess reserves, and concludes: *'It will take skill – as well as political courage – for the Fed to avoid the rise in inflation that the existing liquidity has created'.*

6.3.2. *Australia.* One of the (few) countries that stand in contrast to the U.S. is Australia. As an example of a central bank not playing by the government's political playbook, the Reserve Bank of Australia increased the policy interest rate just seventeen days before the November 2007 federal government election (at a time when other central banks were already reducing their rates). Since the mid-1990s, both major Australian parties have been firmly focused on fiscal discipline which resulted in virtually zero public debt prior to the GFC. There has only been a small increase in debt since then due to the implementation of fiscal stimulus packages - that were in 2009 substantially larger than those in the United States.[22]

These developments suggest a combination of the (AM', AF') and (AM, PF) regimes. They can, in equilibrium, occur with certainty in the Monetary-dominance region, and with some positive probability in the Regime-switching region. Nevertheless, neither regime can occur in the Fiscal-dominance region. This suggests that Australia's $\frac{\text{monetary leadership}}{\text{fiscal leadership}}$ ratio is to the right of the T_M threshold in Figure 5, and likely also to the right of the T_F threshold.

Remark 2. *Based on our theoretic and empirical results, both short-term deflation and long-term excessive inflation are more likely in the United States than in Australia.*

[22] Aizeman and Jinjarak (2011) report the 2009 stimuli to be 2.7% of GDP in Australia and 1.8% of GDP in the U.S.

6.4. **Policy Implications.** Our analysis has several policy implications. First, it implies that it is desirable for countries to ensure the Monetary-dominance region in which both deflation and high inflation are surely avoided in equilibrium.[23] To achieve this over the full course of the business cycle, i.e. for all values of $p \in [0, 1]$, the $\frac{\text{monetary leadership}}{\text{fiscal leadership}}$ ratio needs to be sufficiently high. It must exceed the T_F threshold. Naturally, this ratio can be increased either through higher monetary leadership (e.g. legislating a numerical inflation target and accountability provisions) or through lower fiscal leadership (e.g. structural fiscal reform).

Second, our analysis shows that the implied policy prescription is more nuanced than just 'increase monetary leadership and/or decrease fiscal leadership'. The following remark spells out an implication of Proposition 2 in this respect.

Remark 3. *A higher* $\frac{\textit{monetary leadership}}{\textit{fiscal leadership}}$ *ratio unambiguously improves equilibrium outcomes if and only if it moves the economy to the Monetary-dominance region. An increase in monetary leadership and/or a decrease in fiscal leadership that are insufficiently large may lead to Pareto inferior outcomes.*

Paradoxically, if institutional policy changes move the economy from the Fiscal-dominance region only to the Regime-switching region, there may be no improvement in the Normal times outcomes (high inflation can still occur), there may actually be a worsening of the Downturn outcomes (deflation now becomes a possibility). This important policy warning cannot be obtained from the static Stackelberg leadership framework in which the Regime-switching region does not exist.

It remains an open question whether the January 2012 move of the FOMC attempting to increase the degree of the Fed's leadership by announcing its 2% inflation target may be a case in point. While making the target more explicit and thus moving to the right on the $\frac{\text{monetary leadership}}{\text{fiscal leadership}}$ axis, it falls short of the degree of monetary leadership delivered when such an inflation target is legislated. It is therefore unlikely to catapult the U.S. to the Monetary-dominance region given the large size of the country's fiscal gap [see e.g. Kotlikoff (2006)]. It may in principle only move the U.S. from the Fiscal-dominance to the Regime-switching region where a short-term policy conflict and deflation become more likely.

As a third policy implication, modelling jointly the short-term and long-term horizons sheds different light on the two main fiscal policy prescriptions during 2010-2014, namely 'We need more stimulus to boost the economy' versus 'We need immediate austerity to stop rising debt'. Our analysis implies that these two recommendations may *not* be contradictory, and that they may both be partly wrong.

Our results indicate that if the probability of the Downturn scenario is high countries require a *combination* of short-term stimulus AF' (government spending) and long-term austerity PF (government saving) implemented jointly. In words, there is need for a credible structural fiscal reform that eliminates the expected fiscal gap, which in turn reduces the concerns of a fiscal crisis, and hence enables the government to stimulate the economy in the short-term. This can be through both conventional measures (such as

[23] This is a normative long-term conclusion that does not necessarily apply in all states of the world. As we have seen in the Downturn scenario, a slightly higher inflation may be the optimal short-term solution for certain countries in certain situations.

infrastructure spending) and unconventional measures (issuing more short-term debt). Such conclusion is in line with Leeper (2011).

Unfortunately, many countries have gone the opposite route. They have ignored the need for long-term conceptual fiscal reforms and instead engaged in short-term austerity measures. Such arbitrary budget cuts however seem to inject uncertainty in the economy and halt the recovery, increasing rather than decreasing the debt to GDP ratio.

6.5. **Empirical Support.** Our results are generally consistent with observed developments and empirical evidence. Most notably, our result that a committed central bank is more willing to enter in a conflict with the government is supported by the estimates of Franta et al. (2012). Using time varying parameter VARs, the paper shows that the degree of monetary policy accommodation of debt-financed government spending shocks generally decreased post adoption of an explicit inflation target (or accommodation changed to outright offsetting such shocks by raising interest rates). In contrast, the degree of monetary accommodation has not changed or even increased in the group of non-targeters (the U.S., Switzerland, and Japan) over the same period. Figure 6 offers a sample of the results.

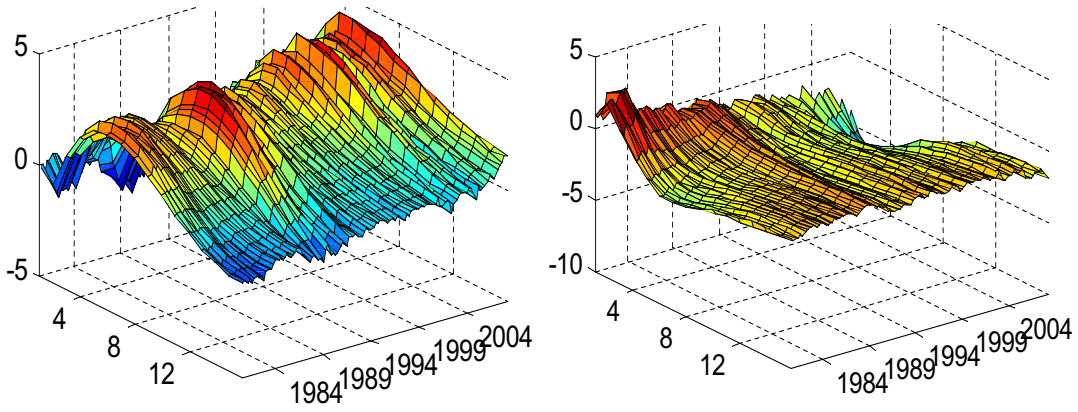

FIGURE 6. Impulse responses of the interest rate (vertical axis) to a debt-financed government spending shock over the 1980-2007 period in Australia (left panel) and the U.S. (right panel). For details see Franta et al. (2012).

Furthermore, the identified disciplining effect of monetary commitment on fiscal policy may explain an additional result of Franta et al. (2012) that in all early inflation targeters (New Zealand, Canada, the U.K., Sweden, and Australia) fiscal outcomes started improving 1-3 years after the adoption of the regime. In contrast, fiscal outcomes have not changed or worsened in major non-targeters over this period. Our results indicate this also: the correlation coefficient between fiscal and monetary leadership scores is -0.51 (see Figure 4 with the early inflation targeters in the bottom right hand corner).[24]

[24]It must however be emphasized that these results provide no evidence of causality. There could in principle be a third common factor responsible for both an adoption of a commitment to an explicit

This is further consistent with the arguments of Brash (2011a,b), the 1988-2002 Governor of the Reserve Bank of New Zealand that pioneered inflation targeting: *'I have not the slightest doubt that having legislation which requires government and central bank to formally agree, and disclose to the public, the inflation rate which the central bank must target has a most useful role in creating strong incentives for good fiscal policy.'*

7. An Extension: a Monetary Union

7.1. **Three Types of Governments.** Our benchmark setup focused on the frequently studied case of a responsible central bank facing an *ambitious* government, F^A [see Faust and Svensson (2001) for the terminology]. This meant that we no longer had the monetary and fiscal 'symbiosis' of Dixit and Lambertini (2003), but a potential coordination problem and/or outright conflict between the policies. This section introduces two additional types of government: *responsible*, F^R, and *ultra-ambitious*, F^U. We do so in the context of a monetary union with a common central bank headed by a responsible governor as in our benchmark specification.[25] But the analysis can also be interpreted as a single country setting in which the central bank has incomplete information about the type of government $i \in \{A, R, U\}$ it is facing.[26]

To allow the latter interpretation and make the analysis illustrative, we will focus on the case in which the timing of fiscal moves is the same across the three types of governments. This seems natural as the principal opportunity of countries to change their fiscal stance happens in the annual budget.

Denote the proportion of the F^A, F^R and F^U types of government in the union by f^A, f^R and f^U respectively, where[27]

$$f^A + f^R + f^U = 1.$$

The overall payoff of the common central bank is an average of the payoffs from interactions with each government type i, using the weights f^i. The payoff of each government type is directly determined by its own stance and that of the common central bank. Indirectly, the actions of other governments in a monetary union also have an impact since they determine the incentives of the common central bank, and hence the equilibrium outcomes.

7.2. **Responsible Fiscal Policymaker.** A responsible government is assumed to prefer the socially optimal outcomes, its payoff satisfying

$$w_R > y_R > z_R > x_R \text{ and } x'_R > z'_R > y'_R > w'_R,$$

inflation target and an improvement in the fiscal balance. Investigation of the political environment at the time suggests that Canada seems to fall in this category.

[25]For an analysis of monetary-fiscal interactions in a currency union see e.g. Kirsanova et al. (2007).

[26]The policy interaction then features two layers of uncertainty: about economic conditions and the opponent's type. Both of them seem realistic in the post-GFC environment.

[27]These proportions can express the relative number of such countries, or can be weighted by their economic size - whichever is more relevant in the particular monetary union. In a single country interpretation, these proportions are the probabilities of the respective government's type as percieved by the central bank.

for example

		F^R	
		PF	AF
M	AM	Ricardian $\mathbf{3}, \mathbf{3}$	explosive (tug-of-war) $1, 1$
	PM	mis-coordination $0, 2$	monetization (spillovers) $2, 0$

Normal times (responsible F)

		F^R	
		PF'	AF'
M	AM'	deflation $0, 0$	recovery $\mathbf{3}, \mathbf{3}$
	PM'	recovery $2, 1$	over-stimulating $1, 2$

Downturn (responsible F)

We have a symbiosis scenario in both the Downturn and Normal times. This is because both games have a unique Pareto-efficient Nash equilibrium, consisting of the preferred outcome for both players and coinciding with the socially optimal outcome $(AM', AF'; AM, PF)$. This means that if all governments in the union are responsible (or, under the single country interpretation, the probability of a responsible government is unity), this outcome will obtain under all parameter values and any timing of moves. Put differently, deflation, over-stimulating, and inflationary fiscal spillovers never occur - even if the degree of monetary leadership is low.

7.3. **Ultra-ambitious Fiscal Policymaker.** We assume that ultra-ambitious governments are unwilling to coordinate with the central bank. This reflects a free-riding problem in a monetary union, present primarily in small member countries. Intuitively, the political benefits of excessive spending (buying votes) accrue predominantly to the indisciplined member government itself, whereas the cost (negative externality) in terms of higher risk and higher interest rates is spread across all union members. Therefore, if a country only forms a small part of the union, and does not internalize this negative externality it imposes on fellow members, it may be unwilling (or politically infeasible) to change its excessive fiscal stance even if the common central bank is known to be pursuing AM.[28] Formally, the payoffs satisfy:

$$z_U > x_U > w_U > y_U \quad \text{and} \quad y'_U > w'_U > x'_U > z'_U,$$

for example

		F^U	
		PF	AF
M	AM	Ricardian $3, 1$	explosive (tug-of-war) $1, 2$
	PM	mis-coordination $0, 0$	monetization (spillovers) $\mathbf{2}, \mathbf{3}$

Normal times (ultra-ambitious F)

		F^U	
		PF'	AF'
M	AM'	deflation $0, 2$	recovery $3, 0$
	PM'	recovery $\mathbf{2}, \mathbf{3}$	over-stimulating $1, 1$

Downturn (ultra-ambitious F)

Both games have a unique Pareto-efficient Nash equilibrium: (PM', PF') and (PM, AF). These equilibria however do *not* coincide with the central banker's preferred and socially optimal outcomes. This means that if all governments in the union are ultra-ambitious, deflation and over-stimulating never occur in the short-term regardless of the degree of monetary leadership. This is because the common central bank is induced to provide

[28] This is reminiscent of Greece in the 2001-2008 period. For a formal modelling of this free-riding in a monetary union see Libich, Savage and Stehlík (2010).

the required stimulus. Nevertheless, inflationary fiscal spillovers occur with certainty, and this is true even if the monetary to fiscal leadership ratio approaches infinity.[29]

7.4. **Results.** Our setup implies that the preferred subgame perfect equilibrium of F^R is the same as M's, whereas F^U shares its preferred equilibrium with F^A. We may therefore see the common central bank joining forces with the responsible governments to better deal with the 'coalition' of the (ultra) ambitious governments. The following result, a generalization of Proposition 2, indicates which coalition dominates, if any.

Proposition 3. *(i)* ***(Ambitious-coalition-dominance)*** *In a currency union, inflationary fiscal spillovers onto monetary policy surely occur if and only if (7) holds. A necessary condition for this is that* ***the proportion of responsible governments is sufficiently low***

$$f^R < \underline{f^R} = \frac{p(c'-a')+(1-p)(d-b)}{p(b'-d'+c'-a')+(1-p)(a-c+d-b)}. \tag{9}$$

Then and only then deflation is surely avoided under all types of government.
(ii) ***(Responsible-coalition-dominance)*** *In a currency union, inflationary fiscal spillovers onto monetary policy surely do not occur if and only if* ***the proportion of responsible governments is sufficiently high***

$$\frac{1}{\int_0^1 (1-R_F(t))\,\mathrm{d}t} > T_F = \frac{f^A\left[p(b'-a')+(1-p)(a-b)\right]}{f^A[p(b'-c')+(1-p)(a-d)]+f^R[p(b'-d')+(1-p)(a-c)]-f^U[p(c'-a')+(1-p)(d-b)]}. \tag{10}$$

A necessary condition for this is

$$f^R \geq \overline{f^R} = \frac{f^U[p(b'-a')+(1-p)(a-b)]-[p(b'-c')+(1-p)(a-d)]}{[p(c'-d')+(1-p)(d-c)]}. \tag{11}$$

If (10) holds then short-term deflation is avoided in countries with responsible and ambitious governments, but it surely occurs in countries with ultra-ambitious governments.
(iii) ***(Regime-switching)*** *If neither (9) nor (10) hold then inflationary fiscal spillovers onto monetary policy may or may not occur in the long-run. Furthermore,* ***deflation may occur in the short-run under all types of governments****.*

Proof. See Appendix D. □

The intuition of our benchmark dynamic leadership results carries over. What determines the outcomes is (i) the degree of monetary leadership of the common central bank relative to the degrees of fiscal leadership of ambitious governments, (ii) uncertainty about the business cycle p, (iii) the policymakers' conflict costs and victory gains in Normal times and Downturn, and also (iv) the proportion of the government types.

[29] An ultra-ambitious government is more likely in a currency union not only because the common central bank cannot effectively punish mis-behaving governments, but also because financial markets tend to defer their punishment (raising the risk premium) due to the likely bailout by fellow members. The situation in the Eurozone prior to 2008 can be used as an example.

7.5. **Policy Insights.** A contribution of this section is to show how responsible governments potentially improve the outcomes of both monetary and fiscal policies, and (free-riding) ultra-ambitious governments make them worse. In particular, if countries with responsible governments make up a large enough part of the monetary union, then a strongly committed central bank is willing to undergo the conflict with the remaining ambitious and ultra-ambitious governments. It knows that ambitious governments will comply in both the short-term and long-term, and hence the exit strategy will be successful. Nevertheless, the ultra-ambitious governments will not do so, which will in such countries lead to a double-dip recession/deflation in the short-term, and continued fiscal excesses in the long-term. Obviously, this may mean a forced departure of such a country from the monetary union.

The opposite case is worth emphasizing. If the monetary union is composed primarily of ultra-ambitious governments (or, in the single country interpretation, the central bank perceives the probability of the ultra-ambitious government type to be above a certain threshold), then even an infinitely strong monetary leadership may not ensure avoiding fiscal inflation. Formally, if $f^R < \overline{f^R}\left(f^U\right)$ then the T_F threshold in (10) does not exist. Hence even if all types of government can revise their stance instantly, $\int_0^1 R_F(t)\mathrm{d}t = 1$, the conflict with the F^U government types would be too costly for the central bank. This means that in Figure 2 there would only be two rather than three equilibrium regions: the Monetary-dominance region disappears.

It will be interesting to follow the developments in the European monetary union. As Figure 3 shows, the degree of fiscal leadership of most of its member countries (including the large ones) is fairly high. This, combined with the strong legal commitment of the European Central Bank to price stability, points to the Regime-switching region. In the Downturn scenario, this region may yield a waiting game with the (AM', PF') regime featuring fiscal austerity, insufficient monetary stimulus, and hence a protracted recession possibly with deflation. This is arguably a description of the 2010-2014 situation in some Eurozone countries. In the Normal times scenario, the Regime-switching region implies that above-target inflation may occur further down the track.

8. Summary and Conclusions

The post Global financial crisis situation of continued economic weaknesses combined with dire long-term fiscal projections has posed unprecedented challenges for policy-makers. The paper attempts to provide some insights into the possible macroeconomic outcomes, and offer some policy recommendations - both in a single country and a currency union setting.

To do so we postulate a game theoretic framework with generalized timing of moves developed in Libich and Stehlík (2011). This allows us to examine the *strategic* aspect of monetary-fiscal policy interactions, unaccounted for in standard macroeconomic models. Our analysis provides a link between the short-run (stabilization) considerations and long-run (sustainability) considerations under incomplete information about the business cycle conditions.

Allowing for stochastic revisions and asynchronous timing of actions enables us to postulate the concept of dynamic leadership. It relates to the monetary and fiscal policies' inability to alter their previous stance. We show that the outcomes of the policy

interaction, both short-term and long-term, depend on the relative degree of the policies' leadership as well as business cycle uncertainty, and the central bank's and government's specific preferences. This is because all these variables affect the magnitude of a potential policy conflict in various phases of the business cycle, and hence the policymakers' payoffs.

In addition to the standard Monetary-dominance and Fiscal-dominance equilibrium regions of Sargent and Wallace (1981), we identify an intermediate Regime-switching region in which the intuition differs from conventional results. Most strikingly, deflation can occur in the aftermath of an adverse shock due to a dead-lock (waiting game) between the central bank and the government. Our results do not only apply to the unpleasant monetarist arithmetic and fiscal theory of the price level literatures, but generally relate to any monetary-fiscal interaction paper that features a coordination problem and/or conflict between the policies.

In Section 6 we relate our findings to the real world. We first quantify the degrees of fiscal and monetary leadership in high-income countries, and then match them to the three equilibrium regions in order to hypothesize about the likely outcomes of the policy interaction. It is for example shown that, unlike Australia and New Zealand, the United States are unlikely to be in the optimal Monetary-dominance region. Hence the danger of both deflation in the short-term and high inflation in the long-term should not be underestimated.

The section then offers some policy recommendations to ensure undesirable macroeconomic outcomes are avoided. While more research is required to provide definitive prescriptions for individual countries, the paper offers a general lesson: monetary policy may need to be committed very explicitly to a numerical target for average inflation to avoid fiscal pressures and spillovers. Such legislated target serves as the central bank's credibility insurance over the business cycle. Without strong monetary leadership, the exit strategy of central banks from the extraordinary stimulatory actions during the GFC may prove unsuccessful.

Interestingly, we show that such legislated long-term commitment to price stability may not only improve the outcomes of monetary policy, but also discipline the government and lead to superior long-term fiscal outcomes too. This is because it increases the chances of a monetary leadership, which reduces the payoffs of governments from avoiding required fiscal reforms.

Let us mention that our monetary leadership concept is compatible with the timeless perspective commitment of Woodford (1999) or quasi-commitment of Schaumburg and Tambalotti (2007). This is because it does not prescribe (a rule for) *how* actions need to be dynamically changed in response to disturbances, it only restricts the frequency with which the policy stance can be altered. This implies that an explicit numerical target for average inflation does not necessarily reduce the policy's flexibility to respond to shocks: for formal modelling of this see Libich (2011), for empirical evidence Parkin (2013). This is also in line with how central bankers view their job. For example, Brash (2011a) reflects on his experience as the world's first inflation targeting central bank Governor as follows: *'An inflation target is only a strait jacket if it is badly designed. All those with which I'm familiar allow for monetary policy to respond flexibly and predictably to exogenous shocks...'*

Section 7 extends the analysis to the case of a currency union, and shows that the disciplining of fiscal policy through monetary leadership may be ineffective against some (ultra-ambitious) types of governments. These are more likely to appear in a monetary union due to incentives for free-riding by small member countries, and hence such unions are more susceptible to departures from price stability. Therefore, they need even stronger checks and balances to prevent fiscal profligacy.

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Appendix A. Real World Fiscal Stress

The 2011 Global Risks Barometer by the World Economic Forum highlights the consensus on the gravity of the fiscal problem. It evaluates the main risks facing the world based on responses from over 500 experts and decision-makers. Out of the 37 economic, geopolitical, societal, environmental and technological risks, 'fiscal crises' are the number one risk in terms of the perceived financial losses, and they are seen as 'very likely to occur in the next ten years'.

It should be stressed that the implemented post-2008 fiscal stimuli only form a small part of the observed fiscal stress facing advanced countries. For example, IMF (2009) estimated that in G20 countries the average contribution of the GFC to the long-term fiscal imbalance was only 10.8% of the contribution of aging populations related factors. Specifically, the paper reports the net present value of the impact of aging-related spending on fiscal deficits in the order of hundreds of percent of GDP for virtually all advanced countries. Even in the United States, where the demographic factors are less unfavourable than the average of advanced economies, Batini, Callegari, and Guerreiro (2011) estimate that: *'a full elimination of the fiscal and generational imbalances would require all taxes to go up and all transfers to be cut immediately and permanently by 35 percent.'*[30]

For illustration of the demographic driving forces the United Nations data can be used. They show that between 1960 and 2040 the old-age dependency ratio in advanced economies is predicted to more than triple on average, with most of the rise yet to come. This implies dramatic increases in the pensioner/worker and total dependency ratios:

[30]See also Neck and Sturm (2008).

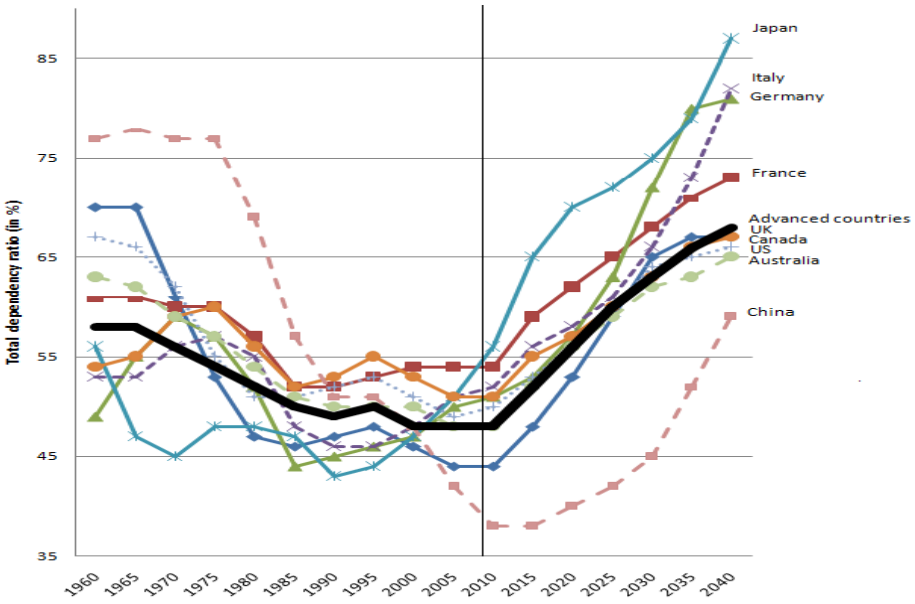

FIGURE 7. The total dependency ratio (population aged 0-14 or 65+ over population aged 15-64) in selected countries, and the mean for advanced countries. United Nations (World Population Prospects) data, 1960-2010 actual, 2011-2040 forecast.

for the latter see Figure 7. In fact, this does not reveal the full extent of the problem. As Bongaarts (2004) reports, the actual pensioner per worker ratio in advanced economies is commonly 50-100% higher than the old-age dependency ratio.[31]

APPENDIX B. PROOF OF PROPOSITION 2

Proof. Focus on claim (i) whereby F is the leader. Solving by backwards induction, F knows that when M's revision opportunity comes up, M will play his static best response to F's initial play: both in the Downturn and Normal times. Therefore, for F to dominate the game and always play PF' and AF, it is required that F is willing to undergo a costly conflict with M: both in the Downturn and Normal times. In other words, both PF' and AF have to be the unique best responses not only to PM' and PM respectively, but also to AM' and AM respectively. This will be the case if the subsequent (post-revision) victory gain is sufficiently high to compensate F for the initial

[31]The fact that both advanced and emerging countries such as China face aging populations implies that the 'global saving glut' situation of the early 2000s is going to get dramatically reversed. More research is required to examine the many implications for of this for capital and labour markets.

conflict cost. Formally, the following incentive compatibility condition needs to hold:

$$p\left(\overbrace{\underbrace{w'\int_0^1 (1-R_M(t))\,\mathrm{d}t}_{(AM',PF')\text{: conflict}}+\underbrace{y'\int_0^1 R_M(t)\mathrm{d}t}_{(PM',PF')\text{: victory}}}^{\text{Downturn}}\right)+(1-p)\left(\overbrace{\underbrace{x\int_0^1 (1-R_M(t))\,\mathrm{d}t}_{(AM,AF)\text{: conflict}}+\underbrace{z\int_0^1 R_M(t)\mathrm{d}t}_{(PM,AF)\text{: victory}}}^{\text{Normal times}}\right)>$$

$$\underbrace{px'}_{(AM',AF')\text{: surrender (Downturn)}}+\underbrace{(1-p)\,w}_{(AM,PF)\text{: surrender (Normal times)}}.$$

Rearranging yields condition (7) and proves claim (i). The proof of claim (ii), made under M being the leader, is analogous due to the symmetry. The proof also implies that unless both (7) and (8) hold there exist multiple types of subgame perfect equilibrium payoffs, so neither player dominates. This means that both short-term deflation and long-term inflationary spillovers may occur in this intermediate Regime-switching region. □

Appendix C. Quantification of Fiscal and Monetary Leadership

Table 2 summarizes the eight measures of fiscal leadership that enter our overall index with equal weights. Measures 1-2 reflect past outcomes, measures 3-7 are based on the projected future outcomes, and measure 8 expresses fiscal governance, which is their important determinant. The 'under-representation' of the commonly used measures 1-2 reflects the fact that the much larger size of the fiscal gap appears in the future.

<table>
<tr><td>Measure</td><td>F1</td><td>F2</td><td>F3-5</td><td>F6-8</td></tr>
<tr><td>Measure name</td><td>Fiscal Balance</td><td>Fiscal Space</td><td>Fiscal Space</td><td>Fiscal Responsibility</td></tr>
<tr><td>Measure by</td><td>IMF</td><td>Aizenman & Jinjarak (2011)</td><td>Ostry et al. (2010)</td><td>Augustine et al. (2011)</td></tr>
<tr><td>Data period</td><td>Average 2001-11</td><td>Average 2001-11</td><td>Projected future</td><td>Projected future</td></tr>
<tr><td rowspan="5">Measure type</td><td rowspan="5">Budget surplus to GDP</td><td rowspan="5">Public debt to GDP over tax base to GDP</td><td>Probability of F space (% GDP)</td><td colspan="2">6. F space | 7. F path
% GDP to debt ceiling | # years to debt ceiling</td></tr>
<tr><td>3. $FS > 0$</td><td colspan="2" rowspan="3">8. F governance index out of 100</td></tr>
<tr><td>4. $FS > 50$</td></tr>
<tr><td>5. $FS > 100$</td></tr>
</table>

Table 2. Components of our fiscal leadership index.

Table 3 summarizes the four measures of monetary leadership that enter our overall index with equal weights. Table 4 reports the data from the papers of Tables 2-3. It should be said that our ranking of countries is fairly robust to alternative weighting of the underlying measures due to their positive correlation, see Table 5. Iceland and Hungary are two non-Eurozone exceptions whereby some of their post-GFC developments may not be fully captured. A more important exception are countries using (or pegged to)

Measure	M1	M2	M3	M4
Measure name	Political Transparency	Final Responsibility	Inflation Focus	Accountability
Measure by	Eijffinger & Geraats (2006)	Haan et al. (1999)	Fry et al. (2000)	Fry et al. (2000)
Quantified by	Dincer & Eichengreen (2009)	Sousa (2002)	Fry et al. (2000)	Fry et al. (2000)
Data period	Average 1998-2006	2002	1998	1998
Measure type	index out of 3	index out of 6	index out of 100	index out of 100

TABLE 3. Components of our monetary leadership index.

the Euro because they no longer have autonomous monetary policy. For this reason we have not included these countries in Figure 5, and indicated them in blue in Figure 4.[32]

To adjust for different units of the underlying measures we normalize all values on the $[0, 1]$ interval. For the measures that do not have a natural lower and/or upper bound we assign the polar values 0 and 1 to the minimum and maximum appearing in our sample. Table 6 reports the resulting scores, as well as their ratio and country ranking.

APPENDIX D. PROOF OF PROPOSITION 3

Proof. Focus on claim (i) in which M is the reviser, and solve backwards. When M's revision opportunity arrives his best response to the ambitious governments' (PF', AF) must uniquely be (PM', PM). Formally, we have the following necessary condition

$$\begin{aligned} &p\left(f^A c' + f^R d' + f^U c'\right) + (1-p)\left(f^A d + f^R c + f^U d\right) > \\ &p\left(f^A a' + f^R b' + f^U a'\right) + (1-p)\left(f^A b + f^R a + f^U b\right), \end{aligned} \tag{12}$$

which, after rearranging, yields (9). Intuitively, the proportion (probability) of the F^A and F^U types, relative to the F^R type, has to be sufficiently high to sway M to comply with them. If satisfied, the central bank would choose to go into conflict with the F^R government types rather than the F^A and F^U types to minimize its associated conflict cost. This is despite the fact that the bank is responsible.

Moving backwards, at time $t = 0$ both the F^A and F^U types of government have to play uniquely (PF', AF) in equilibrium, regardless of M's initial play. For F^U this is automatically satisfied (as she has a strictly dominant strategy in the underlying game), and for F^A this is - assuming (12) holds - ensured by (7) derived in the benchmark specification. Then we know that the exit strategy will surely be unsuccessful, as M will play (PM', PM) from $t = 0$. In terms of claim (ii), M knows that while the actions of

[32]Our reported scores for these countries, which should be taken with great caution, combine the values for the European Central Bank (where available, namely measures M1 and M2), and values for the individual countries (M4). We have excluded measure M3 since it reflected the fixed exchange rates within the Eurozone just prior to its inception.

Measure	F1	F2	F3	F4	F5	F6	F7	F8	M1	M2	M3	M4
Australia	0.26	0.66	99.8	99.5	99.5	168	40+	65.9	3	5	94	83
Canada	-0.78	2.09	92.2	92.1	70.3	106	39	51.5	3	4	88	100
Hungary	-5.32	1.71	-	-	-	53.2	12	46.1	2.67	2	19	83
Iceland	-0.73	2.28	49.1	44	5.8	17.1	20	20.2	3	4	19	92
Japan	-6.7	7.75	0.1	0.1	0.1	49	5	47.2	1.5	3	50	50
Korea	1.63	1.42	100	100	100	124.9	40+	27.5	3	4	63	83
New Zealand	0.88	1.11	93.3	93	92.1	164	38	68.5	3	4	94	100
Norway	13.19	0.97	100	100	100	171.6	22	47.9	2	5	0	50
Poland	-5.08	1.44	-	-	-	94.9	31	58	2.89	3	94	58
Sweden	0.8	0.69	99.9	99.9	99.9	154	40+	59	2.44	1	100	83
UK	-4.6	2.18	78.1	75.9	8.9	91	27	66.4	3	4	100	100
USA	-5.52	3.09	71.8	52.2	1.2	62	16	46	1	2	19	83
Austria	-2.28	1.48	97.9	97.8	75.1	76.4	12	67.8	3*	1*	-	67
Belgium	-1.61	1.93	95.9	89.7	2.9	42.3	8	61.2	3*	1*	-	33
Denmark	1.06	0.8	100	100	100	153.1	34	54.7	2	2	-	75
Finland	2.04	0.95	96.2	96	69.3	99.2	13	57.9	3*	1*	-	92
France	-4.06	1.74	88.7	86.6	12	58.7	15	62.8	3*	1*	-	83
Germany	-2.46	1.87	93	92.3	35.3	75.7	18	57.4	3*	1*	-	17
Greece	-7.64	4.21	6.3	0.1	0.1	0	0	45	3*	1*	-	33
Ireland	5.2	3.21	66	55.9	1.7	38.1	6	48.4	3*	1*	-	83
Italy	-3.54	2.67	17.3	1.7	0.2	17.8	7	59.2	3*	1*	-	58
Netherlands	-1.9	1.46	99.3	99.2	83.1	92.7	12	72.3	3*	1*	-	83
Portugal	-3.47	2.62	34.4	27.1	0.4	27.8	5	45.1	3*	1*	-	83
Slovakia	-4.59	1.3	-	-	-	107.7	33	50.9	3*	1*	-	67
Spain	-2.5	1.77	69.9	61	1.6	81.5	12	60.7	3*	1*	-	83

TABLE 4. Original values of the underlying measures from Tables 2-3 (- indicates no data available, for the meaning of * see footnote 32).

F^R and F^U type governments are independent of M's actions, the F^A type's revision will be the static best response to M's initial play. Using this information implies that for M to uniquely play (AM', AM) the following incentive compatibility has to hold

$$f^A\left\{p\left[a'\int_0^1(1-R_F(t))dt + b'\int_0^1 R_F(t)dt\right] + (1-p)\left[b\int_0^1(1-R_F(t))dt + a\int_0^1 R_F(t)dt\right]\right\} + f^R[pb' + (1-p)a] + f^U[pa' + (1-p)b] > f^A[pc' + (1-p)d] + f^R[pd' + (1-p)c] + f^U[pc' + (1-p)d].$$

After rearranging, we obtain (10), which is just a generalized version of (8). Equation (10) suggests that if its denominator is non-positive then the T_F threshold does not exist. This implies the necessary condition (11) and completes the proof. □

Measure	F1	F2	F3	F4	F5	F6	F7	F8	M1	M2	M3	M4
F1	-	0.59	0.57	0.62	0.69	0.63	0.29	-0.07	-0.17	-0.44	0.32	0.32
F2	0.59	-	0.94	0.92	0.70	0.66	0.80	0.20	-0.56	-0.23	-0.25	-0.46
F3	0.57	0.94	-	0.98	0.79	0.78	0.84	0.30	-0.45	-0.19	-0.31	-0.39
F4	0.62	0.92	0.98	-	0.85	0.83	0.88	0.33	-0.54	-0.26	-0.38	-0.35
F5	0.69	0.70	0.79	0.85	-	0.91	0.79	0.26	-0.42	-0.24	-0.32	0.00
F6	0.63	0.66	0.78	0.83	0.91	-	0.69	0.58	-0.28	-0.24	-0.39	0.04
F7	0.29	0.80	0.84	0.88	0.79	0.69	-	0.31	-0.73	-0.14	-0.67	-0.58
F8	-0.07	0.20	0.30	0.33	0.26	0.58	0.31	-	-0.09	0.01	-0.66	-0.19
M1	-0.17	-0.56	-0.45	-0.54	-0.42	-0.28	-0.73	-0.09	-	0.49	0.57	0.64
M2	-0.44	-0.23	-0.19	-0.26	-0.24	-0.24	-0.14	0.01	0.49	-	-0.10	-0.01
M3	0.32	-0.25	-0.31	-0.38	-0.32	-0.39	-0.67	-0.66	0.57	-0.10	-	0.57
M4	0.32	-0.46	-0.39	-0.35	0.00	0.04	-0.58	-0.19	0.64	-0.01	0.57	-

TABLE 5. Cross-correlation of our institutional measures.

Country	Code	F leadership		M leadership		M vs F leadership scores	
		Score	Rank	Score	Rank	Ratio	Rank
Australia	AUS	0.19	24	0.93	2	4.94	1
Canada	CAN	0.35	16	0.91	4	2.61	6
Hungary	HUN	0.63	7	0.52	16	0.82	18
Iceland	ISL	0.70	5	0.71	7	1.01	15
Japan	JAP	0.89	1	0.41	20	0.46	24
Korea	KOR	0.31	19	0.79	5	2.57	7
New Zealand	NZL	0.21	21	0.92	3	4.30	2
Norway	NOR	0.18	25	0.47	19	2.68	5
Poland	POL	0.49	11	0.72	6	1.46	12
Sweden	SWE	0.21	22	0.63	9	3.03	4
UK	GBR	0.48	14	0.94	1	1.96	9
USA	USA	0.63	8	0.31	25	0.49	23
Austria	AUT	0.34	17	0.53	15	1.56	11
Belgium	BEL	0.49	12	0.40	21	0.81	19
Denmark	DEN	0.23	20	0.48	18	2.13	8
Finland	FIN	0.33	18	0.63	8	1.94	10
France	FRA	0.48	13	0.60	10	1.24	13
Germany	GER	0.43	15	0.33	24	0.77	21
Greece	GRE	0.87	2	0.40	21	0.46	25
Ireland	IRL	0.65	6	0.60	10	0.92	16
Italy	ITA	0.75	3	0.50	17	0.66	22
Netherlands	NED	0.2	23	0.60	10	3.05	3
Portugal	POR	0.73	4	0.60	10	0.82	17
Slovakia	SVK	0.49	10	0.39	23	0.78	20
Spain	ESP	0.54	9	0.60	10	1.12	14

TABLE 6. Our monetary and fiscal leadership indices and their ratio.